Scientific Inquiry

5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.

5-1.3 Plan and conduct controlled scientific investigations, manipulating one variable at a time.
Taxonomy Level: 6.2 and 3.1 Create and Apply Conceptual Knowledge

Previous/Future knowledge: In 1st grade (1-1.3), students carried out simple scientific investigations when given clear directions. In 2nd grade (2-1.1), students carried out simple scientific investigations to answer questions about familiar objects and events. In 4th grade, students summarized the characteristics of a simple scientific investigation that represent a fair test (including a question that identifies the problem, a prediction that indicates a possible outcome, a process that tests one manipulated variable at a time, and results that are communicated and explained) (4-1.3) and constructed and interpreted diagrams, tables, and graphs made from recorded measurements and observations (4-1.6). In 7th grade, students will explain the reasons for testing one independent variable at a time in a controlled scientific investigation (7-1.3) and will explain the importance that repeated trials and a well-chosen sample size have with regard to the validity of a controlled scientific investigation (7-1.4). In 8th grade, students will design a controlled scientific investigation (8-1.1) and will explain the importance of and requirements for replication of scientific investigations (8-1.5).

It is essential for students to know that a *controlled scientific investigation* determines the effect of an independent variable in an experiment, when all other variables are controlled. Every controlled scientific investigation provides information. This information is called *data*. Data includes both scientific observations and inferences.

- A *scientific observation* is gained by carefully identifying and describing properties using the five senses or scientific tools and can be classified as *quantitative* or *qualitative*.
  - Quantitative observations are observations that use numbers (amounts) or measurements (including the unit label) or observations that make relative comparisons, such as more than, all, less than, few, or none.
  - Qualitative observations are observations that are made using only the senses and refer to specific properties.
- An *inference* is an explanation or interpretation of an observation based on prior experiences or supported by observations made in the investigation. They are not final explanations of the observation. There may be several logical inferences for a given observation. There is no way to be sure which inference best explains the observation without further investigation.

In order to design a *controlled scientific investigation* some or all of the following steps should be included:

- Identify a testable question (tests one variable) that can be investigated
- Research information about the topic
- State the hypothesis as a predicted answer to the question, what may be the possible outcome of the investigation
- Design an experiment to test the hypothesis, controlling all variables except the independent (manipulated) variable
  - Plan for independent (manipulated) and dependent (responding) variables
  - Plan for factors that should be held constant (controlled variables)
  - List the materials needed to conduct the experiment
  - List the procedures to be followed
  - Plan for recording, organizing and analyzing data

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- Conduct the experiment and record data (observations) in tables, graphs, or charts
- Analyze the data in the tables, graphs, or charts to figure out what the data means (describe the relationship between the variables)
- Compare the results to the hypothesis and write a conclusion that will support or not support the hypothesis based on the recorded data
- Communicate the results to others

It is essential for students to conduct a controlled scientific investigation after planning the experimental design.

- Appropriate tools should be selected and used.
- Appropriate safety precautions should be taken when conducting the investigation.
- Measurements and observations should be recorded accurately in the appropriate table, chart, or graph.

It is not essential for students to design or conduct an experiment that includes a controlled set-up (7-1.3).

Assessment Guidelines:

One objective of this indicator is to *plan* controlled scientific investigations, manipulating one variable at a time; therefore, the primary focus of assessment should be to design the procedures for completing a scientific investigation where one variable is manipulated. However, appropriate assessments should also require students to *recognize* steps appropriate for conducting a controlled investigation; *detect* inappropriate steps in a given investigation; or *organize* the results of the investigation in tables or charts.

Another objective of this indicator is to *conduct* controlled scientific investigations, manipulating one variable at a time; therefore, the primary focus of assessment should be to carry out the procedures for completing a scientific investigation where one variable is manipulated. However, appropriate assessments should also require students to *summarize* the steps of a controlled investigation; *use* appropriate tools and safety precautions when conducting the investigation; *identify* appropriate tools for an investigation; *recognize* measurements and observations that are accurate and inaccurate in an investigation.